Abstracts of Bell System Technical Papers* Not Published in this Journal

BENNETT, W.[1]

Telephone-System Applications of Recorded Machine Announcements, A.I.E.E., Trans., Commun. & Electronics **8,** pp. 478–483, Sept., 1953.

BIELING, D., see D. EDELSON.

BIGGS, B. S.[1] and W. L. HAWKINS[1]

Oxidative Aging of Polyethylene, Modern Plastics, **31,** pp. 121–122, 124+, Sept., 1953 (Monograph 2155).

Thermal oxidation of polyethylene follows the pattern set by lower homologues such as paraffinic waxes and oils. It is an autocatalytic free radical chain reaction and is subject to inhibition by typical antioxidants. The rate of degradation in the dark at room temperatures is found to be extremely low. Photo-oxidation of polyethylene is rapid in contrast with that of saturated low molecular weight aliphatic hydrocarbons. Furthermore, antioxidants are of little benefit in protecting against exposure to light. Opaque pigments are of great value in reducing the effects of light, finely divided carbon black being particularly effective. By proper compounding polyethylene can be made to last many years outdoors.

BOZORTH, R. M., see H. J. WILLIAMS.

BROWN, W. L.[1]

n-Type Surface Conductivity on p-Type Germanium, Phys. Rev., **91,** pp. 518-527, Aug. 1, 1953 (Monograph 2173).

* Certain of these papers are available as Bell System Monographs and may be obtained on request to the publication Department, Bell Telephone Laboratories, Inc., 463 West Street, New York 14, N. Y. For papers available in this form, the monograph number is given in parentheses following the date of publication, and this number should be given in all requests.

[1] Bell Telephone Laboratories.

A positive charge on the surface of a p-type germanium crystal induces a net negative space charge within the crystal adjacent to the surface. This space charge is composed of ionized acceptor atoms and also of electrons under certain conditions. When electrons occur they provide a layer of n-type conductivity immediately under the p-type germanium surface. Such a layer has been found on the p-type region of some n-p-n-transistors. In the n-p-n structure the layer of electrons appears as an extra conducting path—"a channel"—across the p-type material between the two n-type ends. The conductance of a channel and the capacity between the channel and the p-type material have been measured and compared with the theoretical predictions based on a simple model

CORNELL, L. P., see E. P. SMITH.

CRANE, G. R.[4], F. HAUSER[4] AND H. A. MANLEY[4]

Westrex Film Editor, J.S.M.P.T.E., **61,** Part 1, pp. 316–323, Sept., 1953.

This paper describes a film-editing machine which employs continuous projection resulting in quiet operation. It accommodates standard-picture and photographic or magnetic sound film as well as composite sound-picture film. Differential synchronizing of sound and picture while running, automatic fast stop and simplified threading features in the film gates with finger-tip release materially increase operating efficiency.

CRISSMAN, L.[3]

See Both Sides of the Game, Tele-Tech., **12,** p. 84, Sept., 1953.

DACEY, G. C.[1] AND I. M. ROSS[1]

Unipolar "Field-Effect" Transistor, I.R.E., Proc., **41,** pp. 970–979, Aug., 1953.

Unipolar "field-effect" transistors of a type suggested by W. Shockley have been constructed and tested. The idealized theory of Shockley has been extended to cover the actual geometries involved, and design nomographs are presented. It is found that these structures can be designed in such a way as to yield a negative resistance at the input terminals. The characteristics of several units are presented and analyzed. It is shown that these characteristics are in substantial agreement with the extended theory. Finally a speculative evaluation of the possible future applications of field effect transistors is made.

[1] Bell Telephone Laboratories.
[3] Western Electric Company.
[4] Westrex Corporation.

EDELSON, D.[1], C. A. BIELING[1] AND G. T. KOHMAN[1]

Electrical Decomposition of Sulfur Hexafluoride, Ind. and Eng. Chem., **45,** pp. 2094–2096, Sept., 1953.

EHRBAR, R. D., see C. H. ELMENDORF.

ELMENDORF, C. H.[1], R. D. EHRBAR[1], R. H. KLIE[7], AND A. J. GROSSMAN[1]

The L3 Coaxial System, A.I.E.E., Trans. Commun. & Electronics, **8,** pp. 395–413, Sept., 1953.

The L3 coaxial system is a new broad-band facility for use with existing and new coaxial cables. It makes possible the transmission of 1,860 telephone channels or 600 telephone channels and a television channel in each direction on a pair of coaxial tubes. The principal system design problems and the methods used in their solution are described in terms of its components and their location in the system.

FINE, M. E.[1]

C_p-C_v in Silicon and Germanium, Letter to the Editor, J. Chem. Phys., **21,** P. 1427, Aug., 1953.

FRAYNE, J. G.[4] AND E. W. TEMPLIN[4]

Stereophonic Recording and Reproducing Equipment, J.S.M.P.T.E., **61,** Part 2, pp. 395–407, Sept., 1953.

This paper describes new stereophonic recording channel equipment including a six-position mixer and portable three-channel recorder. For re-recording, the previously described triple-track recorder-reproducer is available. For review-room and theater reproduction, a theater-type dummy equipped for three-channel stereophonic reproduction is described.

GOERTZ, M., see H. J. WILLIAMS.

GRAMELS, J.[1]

Problems to Consider in Applying Selenium Rectifiers, A.I.E.E., Trans., Commun. & Electronics, **8,** pp. 488–492, Sept., 1953.

GRAY, A. N.[3]

Room-Temperature Compound Process, Mech. Eng., **75,** pp. 625–628, Aug., 1953.

[1] Bell Telephone Laboratories.
[3] Western Electric Company.
[4] Westrex Corporation.
[7] Sandia Corporation.

GROSSMAN, A. J., see C. H. ELMENDORF.

HAGSTRUM, H. D.[1]

Electron Ejection From Ta by He^+, He^{++}, and He_2^+., Phys. Rev., **91,** pp. 543–551, Aug. 1, 1953 (Monograph 2148).

Measurements of total yield (γ_i) and kinetic energy distribution are reported for electrons ejected from tantalum by the ions, He^+, He^{++} and He_2^+ in the kinetic energy range 10 to 1000 ev. The evidence presented indicates that the electrons are released by a collision of the second kind of the ion with the metal surface (potential ejection). One internal secondary electron is produced per incident ion. The probability of this electron escaping is reduced by the possibility of internal reflection at the image barrier at the metal surface. γ_i for the slowest ions is observed to be 0.14, 0.52, and 0.10 for He^+, He^{++}, and He_2^+, respectively. The data presented must be considered representative of gas-covered tantalum, since no gas was observed to desorb from the target on heating to 175°K. γ_i was found not to vary with time after cooling the target indicating rapid re-establishment of the equilibrium gas layer on the surface from within the metal. The work function of the covered Ta surface is found to be ca 4.9 ev, some 0.8 ev higher than that of atomically clean Ta. Considerations based on a theory which includes variation of energy levels near the metal surface show resonance neutralization of He^+ at the covered Ta surface not to be possible. Thus only the so-called direct process of potential ejection occurs, with which conclusion the measured energy limits of ejected electrons are in agreement.

HAUSER, F., see G. R. CRANE

HAWKINS, W. L., see B. S. BIGGS.

HEFFNER, H.[1]

Backward-Wave Tube, Electronics, **26,** pp. 135–137, Oct., 1953.

Electron-stream amplifier utilizing backward-wave mode forms microwave oscillator continuously tunable over a three-to-one bandwidth by a single voltage control. Tubes have been built for frequency centering about 6,000, 10,000 and 50,000 mc.

HENDERSON, O.[5]

Magnetic Amplifier Controls for Rectifier Protecting Underground Metallic Structures Cathodically, Corrosion, **9,** pp. 216–220, July, 1953.

This paper covers the initial attempt on the part of the Ohio Bell Telephone

[1] Bell Telephone Laboratories.
[5] Ohio Bell Telephone.

Company to use a magnetic amplifier to give continuous control of the output of a copper-oxide rectifier used for cathodic protection of underground lead covered cables. The controlled rectifier was designed for use at a location where stray current "end effects" were damaging underground telephone cables and municipal light cables and were threatening high-pressure water mains. When properly adjusted, the output of the rectifier will increase or decrease automatically so that at each instant the amount of forced drainage will be adequate to protect the underground telephone cable sheath but will not be in excess of the value at which neighboring underground metallic structures would become anodic and would thus become subject to corrosion. For satisfactory operation the amplifier had to be designed to give a large gain so that a change in the control voltage of only 0.2 volt (+0.1 to −0.1 volt) would be sufficient to vary the output of the rectifier from practically zero current to full rating. In the installation described in this paper the gain of the magnetic amplifier is in the order of 12,000. The magnetic amplifier type of control is well suited to outdoor installations subject to wide changes in temperature and at remote locations where frequent maintenance inspections are not feasible. The magnetic amplifier has advantages over other available control devices which accomplish this same purpose in that it has no moving parts, no vacuum tubes, batteries, motors, relays or contactors. The magnetic amplifier gives a continuous output control which is superior to the stepped increment changes that result from relay or contactor operation.

JERONE, M. G., see E. P. SMITH.

JOHNSON, J. B.[1] AND K. G. MCKAY[1]

Secondary Electron Emission of Crystalline MgO, Phys. Rev., **91,** pp. 582–587, Aug. 1, 1953 (Monograph 2163).

Secondary emission is measured from single crystals of MgO cleaved along the (100) plane. The maximum ratio of secondary to primary current, δ_{max}, is about 7 at about 1,000 volts and room temperatures. The cross-overs are at 33 volts and far above 5,000 volts. Most probable energy of emission is 1 ev or less. A definite effect of temperature is established, decreasing with increasing temperature, in accord with expectations for an insulator.

JONES, T. A.[1] AND W. A. PHELPS[1]

Level Compensator for Telephotograph Systems, Elec. Eng., **72,** pp. 787–791, Sept., 1953.

To eliminate interference in telephotograph transmission through broadband carrier equipment, it was decided to cancel it from the signal delivered by the carrier facility instead of modifying the carrier equipment. Conse-

[1] Bell Telephone Laboratories.

quently, a recently developed telephotograph level compensator, consisting of a pilot channel arrangement designed for insertion in the telephotograph connecting circuits, is utilized.

KISTLER, R. E.[6]

Radio Links U.S. and Canada, Telephony, **145,** pp. 16–17, 33, Sept. 5, 1953.

KLIE, R. H., see C. H. ELMENDORF.

KOHMAN, G. T., see D. EDELSON.

KRUSE, P. F., JR.[7] and W. B. WALLACE[7]

Identification of Polymeric Materials, Anal. Chem., **25,** p. 1156, Aug., 1953.

KUH, E. S.[1]

Potential Analog-Network Synthesis for Arbitrary Loss Functions, J. App. Phys., **24,** pp. 897–902, July 1953.

A general method is developed for designing networks with arbitrary loss functions based on the potential analogy. An appropriate potential problem is formed on the basis of the given loss function by introducing continuous charge distribution on the complex frequency plane. After the potential problem is solved, the technique of quantization of charge is used to find the natural modes of the network function.

LANGE, R. W.[1]

40- to 4,000-Microwatt Power Meter, A.I.E.E. Trans., Commun. & Electronics, **8,** pp. 492–494, Sept., 1953.

LEWIS W. D.[1]

Electronic Computers and Telephone Switching, I.R.E., Proc., **41,** pp. 1242–1244, Oct., 1953.

Automatic telephone switching and digital computation have much in common. Both rely upon discrete rather than continuous devices. Development of recent switching systems with a close functional resemblance to large digital computers has increased this overlap. The next big step in

[1] Bell Telephone Laboratories.
[6] Pacific Telephone and Telegraph Company.
[7] Sandia Corporation.

telephone switching should be towards electronics. In making this step, switching scientists and engineers can be much helped by modern electronic computer technology. To be successful, they must also contribute to this technology.

LINDHOM, P.[3]

"Feedback" — Heart of Automatic Process Control, Factory, **111,** pp. 106–109, Oct., 1953.

LOGAN, R. A.[1]

Thermally Induced Acceptors in Single Crystal Germanium, Letter to the Editor, Phys. Rev., **91,** pp. 757–758, Aug. 1, 1953.

MAITA, J. P., see M. TANENBAUM.

MALLERY, P.[1]

Transistors and Their Circuits in the 4A Toll Crossbar Switching System, A.I.E.E. Trans., Commun. & Electronics, **8,** pp. 388–392, Sept., 1953.

MALTHANER, W. A.[1] AND H. E. VAUGHAN[1]

Automatic Telephone System Employing Magnetic Drum Memory, I.R.E., Proc., **41,** pp. 1341–1347, Oct., 1953 (Monograph 2151).

The use of magnetic drum memory in an automatic telephone switching office is described. A capacitive scanner acts as a time-division connector through which information generated by subscribers' telephone sets is conveyed to storage on magnetic drums. Information thus accumulated is combined with "permanent" information on the magnetic drums, processed in accordance with built-in programs and dispatched to control call switching circuits. Technical feasibility of this system has been demonstrated by the construction and successful operation of a large-scale laboratory model.

MANLEY, H. A., see G. R. CRANE.

MATTHIAS, B. T.[1]

Superconducting Compounds, Letter to the Editor, Phys. Rev., **91,** p. 413, July 15, 1953.

MCAFEE, K. B., see K. G. MCKAY.

[1] Bell Telephone Laboratories.
[3] Western Electric Company.

McCarthy, R. H.[3]

Organization for Production Engineering, Mech. Eng., **75,** pp. 785–788, 793, Oct., 1953.

McGuigan, J. H.[1]

Combined Reading and Writing on a Magnetic Drum, I.R.E., Proc., **41,** pp. 1438–1444, Oct., 1953 (Monograph 2152).

This paper points out that the characteristics of magnetic recording make it possible to combine reading and writing in the same cell as it passes just once under the head. Amplifier requirements for this method of operation are discussed and a suitable design presented. A single head is used for both reading and writing. The process can be repeated in every successive cell at a cell rate of 60 kc. The techniques described, which are applicable to either parallel or serial systems, extend the utility of magnetic drums by allowing date processing as well as data storage.

McKay, K, G., see J. B. Johnson.

McKay, K. G.[1] and K. B. McAfee[1]

Electron Multiplication in Silicon and Germanium, Phys. Rev., **91,** pp. 1079–1084, Sept. 1, 1953 (Monograph 2162).

Electron multiplication in silicon and germanium has been studied in the high fields of wide p-n junctions for voltages in the pre-breakdown region. Multiplication factors as high as eighteen have been observed at room temperature. Carriers injected by light, alpha particles, or thermal-generation are multiplied in the same manner. The time required for the multiplication process is less than 2×10^{-8} second. Approximately equal multiplication factors are obtained for injected electrons and injected holes. The multiplication increases rapidly as "breakdown voltage" is approached. The data are well represented by ionization rates computed by conventional avalanche theory. In very narrow junctions, no observable multiplication occurs before Zener emission sets in, as previously reported. It is incidentally determined that the efficiency of ionization by alpha particles bombarding silicon is 3.6 ± 0.3 electron volts per electron-hole pair produced.

McSkimin, H. J.[1]

Measurement of Elastic Constants at Low Temperatures by Means of Ultrasonic Waves — Data for Silicon and Germanium Single Crystals and for Fused Silica, J. App. Phys., **24,** pp. 988–997, Aug., 1953 (Monograph 2171).

[1] Bell Telephone Laboratories.
[3] Western Electric Company.

Ultrasonic waves (shear on longitudinal) in the 10-30 mc range are transmitted down a fused silica rod, through a polystyrene or silicone one-quarter wavelength seal, and into the solid specimen. Measurement of reflections within the specimen yields values for velocities of propagation and elastic constants. Data obtained over a temperature range of 78° to 300°K for silicon and germanium single crystals, and 1.6° to 300°K for fused silica are listed. For the latter, a high loss is noted, with an indicated maximum near 30°K.

MERZ, W. J.[1]

Double Hysteresis Loop of $BaTiO_3$ at the Curie Point, Phys. Rev., **91,** pp. 513–517, Aug. 1, 1953 (Monograph 2166).

It is known that the Curie point of the ferroelectric $BaTiO_3$ shifts to higher temperatures when a dc bias field is applied. If the crystal shows a sharp transition, we expect by applying an ac field at the Curie temperature that the crystal would become alternately ferroelectric and nonferroelectric in the cycle of the ac field. This can be seen in the shape of the hysteresis loop at temperatures slightly above θ. In the center of the polarization P versus field E plot, we observe a linear behavior corresponding to the paraelectric state of $BaTiO_3$ above θ. At both high voltage ends, however, we observe a hysteresis loop corresponding to the ferroelectric state. A change in temperature causes a change in size and shape of the double hysteresis loops, ranging from a line with curves at the ends (higher temperature) to two overlapping loops (lower temperature). The results obtained allow us to calculate the different constants in the free-energy expression of Devonshire and Slater. One of the results shows that the transition is of the first order since the P^4 term turns out to be negative. The properties of the hysteresis loops are discussed, especially the large spontaneous electrical polarization and the low coercive field strength.

MOORE, E. F., see C. E. SHANNON.

MORRISON, J.[1]

Leak Control Tube., Rev. Sci. Instr, **24,** pp. 564–547, July, 1953.

PHELPS, W. A., see T. A. JONES.

PRINCE, M. B.[1]

Experimental Confirmation of Relation Between Pulse Drift Mobility and Charge Carrier Drift Mobility in Germanium, Phys. Rev., **91,** pp. 271–272, July 15, 1953 (Monograph 2168).

Experimental data of drift mobilities of minority carriers in germanium are

[1] Bell Telephone Laboratories.

brought into agreement with theoretical predictions by distinguishing between group velocity and particle velocity of a pulse of minority carriers. Corrected high temperature measurements of electron drift mobility are consistent with the theoretical prediction $\mu = AT^{-3/2}$. The experimentally determined value of A is 2.0×10^7 cm^2 deg$^{3/2}$/volt-sec.

Reiss, H.[1]

Chemical Effects Due to the Ionization of Impurities in Semiconductors, J. Chem. Phys., **21,** p. 1209, July, 1953 (Monograph 2172).

This paper contains a theoretical account of the possible effects which the ionization of donor and acceptor impurities can induce in the thermodynamic phase relations involving their solutions with semiconductors. These effects reflect the energy band structure of the semiconductor. Furthermore, the phenomenon has an interest of its own, for within a certain range of experimental conditions the effects can be attributed to a chemical-like, mass action behavior of the electrons which play the roles of negative ions. Section V is a brief discussion of a fine point concerning the Fermi level. It is shown that although the Fermi level is certainly the electronic electrochemical potential, it is not the Gibbs free energy per electron unless the density of electron energy levels is linear in the volume of the system.

Robbins, R. L.[1]

Measurement of Path Loss Between Miami and Key West at 3675 mc., I.R.E., Trans., P.G.A.P. **1,** pp. 5–8, July, 1953.

Radio transmission measurements have been made at 3,675 megacycles on the 130-mile path between Miami and Key West, Florida, which is largely over watery wastes of the Everglades and shallow sea waters of the Florida Keys. Path loss and fading characteristics for this terrain were not found to differ materially from the characteristics of hilly or mountainous paths in the northeastern section of the country.

Ross, I. M., see G. C. Dacey.

Shannon, C. E.

Turing's Formulation of Computing Machines and Von Neumann's Models of Self-reproducing Machines., I.R.E., Proc., **41,** pp. 1235–1241, Oct., 1953 (Monograph 2150).

This paper reviews briefly some of the recent developments in the field of automata and non-numerical computation. A number of typical machines are described, including logic machines, game-playing machines and learning machines. Some theoretical questions and developments are discussed, such as a comparison of computers and the brain.

[1] Bell Telephone Laboratories.

SHANNON, C. E.[1] AND E. F. MOORE[1]

Machine Aid for Switching Circuit Design, I.R.E., Proc., **41,** pp. 1348–1351, Oct., 1953 (Monograph 2153).

Design of circuits composed of logical elements may be facilitated by auxiliary machines. This paper describes one such machine, made of relays, selector switches, gas diodes, and germanium diodes. This machine (called the relay circuit analyzer) has as inputs both a relay contact circuit and the specifications the circuit is expected to satisfy. The analyzer (1) verifies whether the circuit satisfies the specifications, (2) makes systematic attempts to simplify the circuit by removing redundant contacts, and also (3) obtains mathematically rigorous lower bounds for the numbers and types of contacts needed to satisfy the specifications. A special feature of the analyzer is its ability to take advantage of circuit specifications which are incompletely stated. The auxiliary machine method of doing these and similar operations is compared with the method of coding them on a general-purpose digital computer.

SMITH, E. P.[6], L. P. CORNELL[6] AND M. G. JEROME[6]

Co-ordinating M1 and N1 Telephone Carrier Systems, Elec. Eng., **72,** p. 780, Sept., 1953.

TANENBAUM, M.[1] AND J. P. MAITA[1]

Hall Effect and Conductivity of InSb Single Crystals, Letter to the Editor, Phys. Rev., **91,** pp. 1009–1010, Aug. 15, 1953.

TEMPLIN, E. W., see J. G. FRAYNE.

TOWSLEY, L. M., see E. A. WOOD.

TUCKER, C. J., JR.[8]

Emergency Reporting System Installed by Southern Bell, Telephony, **145,** pp. 26, 38, Aug. 29, 1953.

New fire and emergency reporting system utilizing telephone facilities for the general public to make verbal reports of fires and other emergencies — the first of its kind in the nation — was put into service in Miami, Fla., on Aug. 1, by Southern Bell Telephone & Telegraph Co.

VAN ROOSBROECK, W.[1]

[1] Bell Telephone Laboratories.
[6] Pacific Telephone and Telegraph Company.
[8] Southern Bell Telephone Company.

Transport of Added Current Carriers in a Homogeneous Semiconductor, Phys. Rev., **91,** pp. 282–289, July 15, 1953 (Monograph 2165).

Taking into account the thermal equilibrium minority carrier concentration and employing the formulation which includes, as one of two fundamental equations, the continuity equation for added carrier concentration Δp, this equation is derived in a form which exhibits the ambipolar nature of the diffusion, drift, and recombination mechanisms under electrical neutrality. The general concentration-dependent diffusivity is given. The local drift velocity of Δp has the direction of total current density in an n-type semiconductor and the reverse in a p-type semiconductor, differing in general in both magnitude and direction from the minority-carrier drift velocity. Specifying a model for recombination fixes the dependence of a lifetime function for Δp on Δp and the electron and hole mean lifetimes. Negative Δp, or carrier depletion with electrical neutrality, may occur. For known total current density, the continuity equation alone suffices, as for the case of $|\Delta p|$ small, for which the equation is linear. A condition for this comparatively important case is derived, and theoretical relationships are given with the aid of a parameter specifying the Fermi level, which determine for germanium the minority carrier-Δp drift velocity ratio as well as the ambipolar diffusivity and group mobility in terms of resistivity and temperature.

VAUGHAN, H. E., see W. A. MALTHANER.

VOGELSONG, J. H.[1]

Transistor Pulse Amplifier Using External Regeneration, I.R.E., Proc., **41,** pp. 1444–1450, Oct., 1953.

Pulse-regenerative amplifier using a point-contact transistor has been operated at a basic frequency of 3 megacycles. To produce regenerated pulses with waveshapes which are practically independent of the waveshapes of the input pulses, a germanium diode circuit has been used in conjunction with an external feed-back path. This arrangement also provides for the synchronization of the output pulses with a master clock. Transformer coupling has been incorporated into the circuit to provide dc restoration.

WALKER, A. C.[1]

Hydrothermal Synthesis of Quartz Crystals, Am. Ceramic Soc., J., **36,** pp. 250–256, Aug., 1953 (Monograph 2146).

Research at the Bell Telephone Laboratories on the problem of growing large single crystals of quartz has now progressed to a point where it is possible to grow crystals weighing more than 1 lb. each in a period of 60 days or less. Equipment now in use includes autoclaves 4 inches in inside diameter and 4 ft. long, weighing about 1,150 lb. each. In developing the

[1] Bell Telephone Laboratories.

hydrothermal process used to grow these quartz crystals it has been necessary to solve many problems in the little-known field of high pressure. The results point to the possibility of growing other types of crystals, and the field of usefulness of this process now appears to be much more extensive than was the case at the beginning of the investigation in 1946. Of prime importance is the fact that crystals grown from solution are likely to be better formed and of more perfect quality than those grown from the melt or by other methods. Many of the difficulties inherent in this work have been due to corrosion of steel in alkaline solution. This was a rather unexpected problem, since in high pressure steam boilers alkali is added in small amounts to prevent corrosion of the boiler tubes. Such corrosion has been shown to be responsible for the appearance of electrical twinning on the growing faces of the quartz crystals. Other causes of such twinning have also been found in the course of this work.

WALKER, L. R.[1]

Starting Currents in the Backward-Wave Oscillator, J. App. Phys., **24,** pp. 854–859, July, 1953.

The starting current of a simple model of the backward-wave oscillator described by Kompfner and Williams has been calculated. The effect of space charge is included. The starting current I_0 may be written in the form

$$\frac{4V_0}{Z_0}\left[\frac{a_0(4QC)}{2N}\right]^3,$$

where V_0 is the beam voltage, Z_0 is the impedance of the circuit, N is the length of the oscillator in wavelengths measured on the circuit and $a_0(4QC)$ is a dimensionless quantity which has been evaluated as a function of the space-charge parameter $4QC$.

WALLACE, W. B., see P. F. KRUSE, JR.

WASHBURN, S. H.[1]

Application of Boolean Algebra to the Design of Electronic Switching Circuits, A.I.E.E. Trans., Commun. & Electronics, **8,** pp. 380–388, Sept., 1953.

WERNER, D. R.[2]

Effects of Polarization on Telephone Cable Buried Through a Salt Bed, Corrosion, **9,** pp. 232–236, July, 1953.

Cathodic protection has been applied to a copper jacketed cable in a salt lake bed about one mile wide in which the earth resistivity was apparently uni-

[1] Bell Telephone Laboratories.
[2] American Telephone and Telegraph Company.

form at about 20 ohm-centimeters. Current of about one ampere flowed on the copper jacket into the low resistivity areas on either side and was found to be sustained by polarization effects when the cathodic protection current was removed. The current loss on the copper jacket was found to be concentrated in an area about 720 feet wide, 360 feet each side of the point where the cathodic protection current had been drained from the copper jacket. The copper jacket to soil potential tested most negative to a copper sulfate half cell in the 720-foot area where the current loss was concentrated and was of the order of −1.0 to −1.1 volts. Permanent remedial measures will consist of installations of magnesium anodes distributed throughout the low earth resistivity area and insulating joints in the copper jacket at locations where large changes in the earth resistivity occur.

WILLIAMS, H. J.[1], R. M. BOZORTH[1] AND M. GOERTZ[1]

Mechanism of Transition in Magnetite at Low Temperatures, Phys. Rev., **91,** pp. 1107–1115, Sept. 1, 1953 (Monograph 2149).

When magnetite is cooled through −160°C it is known to undergo a transition (cubic to orthorhombic) that is influenced by the presence of a magnetic field. Our experiments are in agreement with the following mechanism of the transition: The orthorhombic c axis is parallel to one of the original cubic axes and is the axis of easiest magnetization. Generally, different regions of the original crystal will transform with their c axes lying along different cubic axes, and when no field is applied there are 6 different orientations which different regions assume. When a field is applied during a cooling a c axis tends to lie along the original cubic axis that is nearest to the applied field, the a and b axis having less but different tendencies to lie parallel to the field. Six magnetic crystal anisotropy constants are derived from torque curves measured in the (100) and (110) planes. From them magnetization curves are calculated for the 100 and 110 directions, and these are in agreement with experiment.

WOOD, E. A.[1] AND L. M. TOWSLEY[1]

Manganese Film-Shield for FeK X-Rays, Rev. Sci. Instr., **24,** p. 547, July, 1953.

[1] Bell Telephone Laboratories.